CHEMICALS

Project Fact Sheet

Microchannel Reactor System Design

Benefits

- Steam usage energy savings of 5 trillion Btu/year
- Reduced electric power consumption by 3 trillion Btu/year
- 10% reduction in feedstock energy use
- 50% reduction in waste disposal costs

Applications

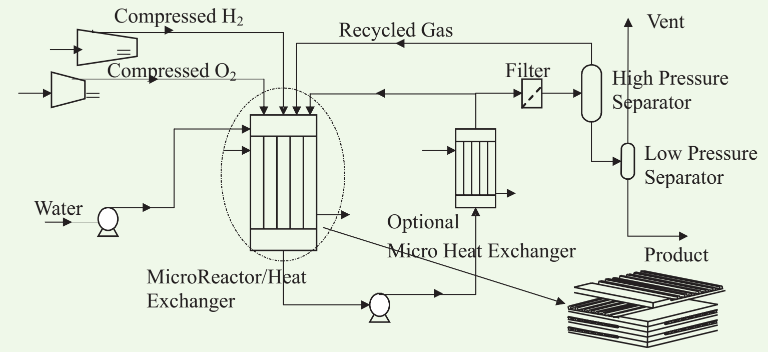
H_2O_2 is a chemical with diverse applications. Its current use ranges from pulp and paper bleaching to health care; water purification where it is considered as an environmentally friendly alternative to chlorine; synthesis of various oxychemicals because of its high selectivity; and effectiveness as an oxidizing agent.

Microchannel Reactor Systems Could Allow for Energy-Efficient and Cost-Effective On-Site Hydrogen Peroxide Production

Hydrogen peroxide (H_2O_2) is commercially manufactured by a process known as autoxidation, which produces H_2O_2 at 70-percent concentration through an energy intensive distillation stage. Because most H_2O_2 commercial applications use a low H_2O_2 concentration (15 wt percent), the 70 percent H_2O_2 solution must be diluted prior to storage and use. End users have increasingly become interested in the concept of on-site, on-demand H_2O_2 generation to reduce transportation costs, storage, and concentration dilution costs. However, combining H_2 and O_2 in conventional reactor systems is not feasible at H_2 concentrations above 5 percent, as the mixture becomes flammable and even explosive. At low H_2 concentrations, the rate of H_2 diffusion in the liquid phase is extremely slow, thus necessitating the use of very high pressures, and rendering the process energy inefficient. The solubility can also be improved by adding H_2SO_4 and halide ions, but both pose serious corrosion and contamination problems.

One approach is on-site direct combination with low-pressure operating conditions, which uses a microchannel reactor. These reactors possess extremely high surface-to-volume ratios and exhibit enhanced heat and mass transfer rates. The microchannel reactor allows for H_2 concentrations above 5 percent without the risk of combustion, while ensuring low-pressure, energy efficient, and safe operation. Considerable potential exists for on-demand production of toxic and explosive chemicals that may be possible with reactor system miniaturization. Estimated energy savings for a successful, fully implemented project are 5 trillion Btu/year of steam energy and 3 trillion Btu/year of electricity. These savings translate to an approximate 30-percent reduction in overall production and transportation costs for the $1 billion H_2O_2 industry.

Microchannel Reactor System



Conceptual Process Flow Diagram for Microchannel Reactor System

Project Description

Goal: The project consists of two phases. The goal of the first phase is to design, fabricate, evaluate, and optimize a laboratory-scale microchannel reactor/heat exchanger system for controlled catalytic oxidation of H_2. This will be achieved via direct combination of H_2 and O_2 in explosive regime at a low pressure and a low temperature to produce up to 15-percent H_2O_2. Once this is accomplished, the goal of the second phase is to demonstrate on-demand production of H_2O_2 at one end-user site in preparation for the commercialization of the technology.

For highly exothermic reactions, the enhanced heat-transfer capabilities of microchannel reactors enable rapid wall quenching of free radicals that in conventional-size reactors leads to thermal runaway conditions and concomitant explosion. The absence of mass-transfer resistance also enables realization of fast intrinsic kinetics.

The energy intensive unit operations of the autoxidation process, which will not be needed for the direct combination process, include: (1) purification and vacuum drying of working solution, (2) solvent recovery system, (3) compression of a large amount of inert N_2, and (4) recompression of a large amount of unreacted N_2. The project's process will consist of a single microreactor scheme, which on a large scale will involve an appropriate increase in the number of bundled/stacked microchannel plates. This yields a simpler and more efficient process when compared to conventional autoxidation.

Progress and Milestones

The seven necessary tasks to accomplish the project goals are summarized below. The first six tasks correspond to the first phase of the project (3 years) and the seventh task to the second phase (2 years).

- Model-based microchannel reactor design
- Microchannel reactor fabrication
- Microchannel reactor studies for model validation
- Nanostructured thin-film catalysts
- Parallel catalyst optimization and kinetics
- Laboratory reactor system evaluation
- Reactor system analysis, optimization, integration and evaluation

Commercialization

Stevens Institute of Technology and FMC Corporation will lead the effort of commercializing the project. The combination of these two leaders in the field provides a powerful base from which technology can be successfully launched into the marketplace. Also, involving end-users (ERM, GCI) and H_2/O_2 supplier (PAEI) at the inception stage will reduce the time associated with the technology development cycle and increase the speed to commercialization.

Project Partners

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FMC Corporation
Princeton, NJ

New Jersey Commission of Science and Technology
Trenton, NJ

Environmental Resources Management
Ewing, NJ

Geo-Cleanse International, Inc.
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